portunities to preserve tallgrass prairie are likely in the Kansas Flint Hills and the few other areas with extensive tracts remaining. Though our rational minds tell us there is perhaps little hope for long-term preservation of the many small prairie fragments scattered across America's heartland, we find it difficult to release our emotional attachment to these small but beautiful pockets of waving grass. Though the prairie lacks the mass appeal of more spectacular ecosystems such as temperate or tropical rain forests, there are fortunately many prairie enthusiasts. Perhaps with dedicated efforts we can preserve the tallgrass prairie so that those who come after us can marvel at its many wonders.

CHAPTER 4

Prairie Ecology—The Mixed Prairie

Thomas B. Bragg
Allen A. Steuter

The mixed prairie occupies the central third of the North American Great Plains. It is bounded by tallgrass prairie to the east, shortgrass prairie to the west, aspen parkland to the north, and juniper-oak savanna to the south (Küchler 1985). This semiarid land is characterized by seasonal moisture and temperature extremes typical of a continental climate. In the northern mixed prairie, annual precipitation increases from 30 cm in the west to 60 cm in the east; the southern precipitation gradient increases from 40 to 80 cm (Bryson and Hare 1974). Two-thirds of the annual precipitation occurs during the growing season, although regional droughts are common. The west-to-east elevation in the north ranges from 1,130 to 400 m.

During most of the Holocene, mixed prairie uplands and lowlands have been dominated by herbaceous vegetation, with woodlands restricted to isolated buttes, scarps, and riparian habitats protected from fire (Axelrod 1985; Wells 1965). Perennial grasses dominate above- and belowground resources and primary production, but forbs are largely responsible for community diversity. Typically, grasses are represented by tens of species, while forb species number in the hundreds. Distribution and abundance of forbs are also more dynamic and diagnostic of changes in moisture, grazing, and fire regimes than is the perennial grass matrix (Biondini et al. 1989; Steuter et al. 1995). Interestingly, with the exception of blowout penstemon, no widely recognized plant species are endemic to the mixed prairie (Stubbendieck et al. 1993). Blowout penstemon is uniquely adapted and confined to the most actively wind-eroded sites in the Nebraska Sandhills prairie.

Humans have played a major role in the evolutionary history of mixed prairie, largely through their use of fire (e.g., Moore 1972; Higgins 1986). Other important species included the wolf, North American bison, prairie dog, and plains pocket gopher. Historically, mixed prairie formed the central portion of the primary bison range (McDonald 1981), attracting vast summer breeding herds because of the region's openness, high-quality forage, and relatively abundant water (Hansen 1984). The faunal component also included wetland species. The mixed prairie landscape is characterized by broad river valleys with gently rolling interfluvial plains. The regular sequence of rivers flowing through the mixed prairie, the prairie potholes of the Dakotas and Canadian provinces, and the sandhill lake regions of Nebraska formed a dispersed and redundant system of critical water and wetland habitats for a diverse array of migratory and nonmigratory species. The region is a central feature of the Great Plains Flyway, a migratory waterbird spectacle that still rivals that of the great bison herds.

The mixed prairie consists of three types, based on plant community structure and function: northern mixed prairie, sandhills prairie, and southern mixed prairie.

Ecology and Distribution

The evolution of the mixed prairie resulted in biota well adapted to grazing (Mack and Thompson 1982; Milchunas et al. 1988) and fire (Wright and Bailey 1982). The mixed prairie is largely a product of these two forces interacting with regional soils, weather, and climate—particularly periodic drought (Weaver and Albertson 1956). The effects of grazing, whether by bison or cattle, are similar in that standing crop is reduced (see table 4.1). Fire also reduces standing crop (Hopkins et al. 1948) and litter (Willms et al. 1993), thus altering species diversity patterns (Biondini et al. 1989), modifying grazing patterns (Coppock and Detling 1986), and variously affecting animals (Bragg 1995). The interaction of fire and grazing often has different effects than either process alone (Pfeiffer and Steuter 1994). Fire and grazing magnify drought stress on mixed prairie vegetation (Mihlbacher et al. 1989). The adverse effects of drought are most severe on little bluestem, and less so on sideoats grama, blue grama, buffalo grass, and western wheatgrass (Weaver 1968). Dynamic shifts in the plant community also occur with fertilization (Rauzi and Fairbourn 1983), woody plant removal (Vallentine 1980), mechanical disturbance of soil (Haferkamp et al. 1993), and mowing (Launchbaugh 1973). As with fire, mowing tends to reduce production during all but high-rainfall years. Fertilization, mostly used in the northern mixed prairie, generally is not economically feasible.

Table 4.1
Representative standing crop from mixed-grass prairies of the North American Great Plains

Location and Treatment	Standing Crop (kg/ha) Treated	Untreated	Reference
Northern mixed			
Grazed	347	395	Hoffman and Ries 1989
	205–400	228–382	Brand and Goetz 1986
	170–360	268–416	Sims et al. 1978
Burned	265	291	Gartner et al. 1986
	357–403	409	Gartner et al. 1978
Sandhills			
Grazed	182(b)	347(b)	Bragg 1978
Burned	131–393	182–440(g)	Bragg 1978
Southern mixed			
Grazed	182	190	Sims et al. 1978
	242	421	Tomanek and Albertson 1953
Burned	820	861	Nagel 1983
	197(g)	390(g)	Hopkins et al. 1948
	444	216	Adams and Anderson 1978

Note: Treatment includes grazing (g) or burning (b).

Northern Mixed Prairie

The original northern mixed prairie covered approximately 38 million ha in Nebraska, North and South Dakota, and Canada. Plant communities included the wheatgrass-bluestem-needlegrass and the wheatgrass-needlegrass associations of Küchler (1985). Cool-season grasses become increasingly more dominant from Nebraska to Canada. Mesic associations of taller species generally occur on lower slopes, transitioning to midheight and then to shorter species associations on the dry hilltops (Barnes et al. 1983). These grasslands occur primarily on loamy glacial tills and clay to clay-loam soils.

Western wheatgrass is the common denominator of the northern mixed prairie type, even though it is not always a dominant (Gartner 1986). Other common grasses include blue grama, needle-and-thread, green needlegrass, and porcupine grass. Without burning, Kentucky bluegrass and smooth brome, cool-season exotics, increase in the northern mixed prairies (Kirsch and Kruse 1973). Forb productivity ranges from 0 to 40 percent of total net primary production

(Lura et al. 1988) but may vary considerably with heavy grazing (Whitma 1974). Several woody species—western snowberry, fringed sagebrush, and eas ern redcedar—have replaced herbaceous species in the region (Wright and Ba ley 1982; Kaul and Rolfsmeier 1993).

In general, grazing favors short-statured, or rhizomatous, species, such a western wheatgrass and blue grama, over taller, or bunchgrass, species, such a little bluestem (Mack and Thompson 1982). Shifts in species composition a more a function of grazing intensity and plant species morphology and repr ductive mechanisms than whether they are cool- or warm-season species (Ode al. 1980; Singh et al. 1983; Brand and Goetz 1986; Schacht and Stubbendiec 1985). Grazing decreases litter, but litter accumulation does not appear to lim productivity (Dix 1960). Although heavy grazing or the exclusion of grazing do not increase decomposition (Shariff et al. 1994), moderate grazing increases d composition and affects soil chemical properties (Dormaar and Willms 199 Thus, grazing is important in maintaining the ecosystem processes that occurr when large number of bison dominated the Great Plains grasslands. Grasses th decrease with grazing include big bluestem and indian grass. Sedges and lea plant are among other species declining with grazing. Blue grama, ironwee western ragweed, and curlycup gumweed increase with increased grazing inte sity (Branson and Weaver 1953; Brand and Goetz 1986).

Fire was a frequent event in the northern mixed prairie (Higgins 1986). general, fire reduces standing crop of both cool- and warm-season species du ing dry years and maintains or increases standing crop in wet years (Engle a Bultsma 1984; Whisenant and Uresk 1990). Fire improves herbage quality a decreases litter (Willms et al. 1980, 1986); it also increases bare ground, allo ing more light to penetrate the canopy during the growing season (Dix 196 Recovery of mulch structure may take at least three years. Reductions in net pr duction and individual species' primary production caused by fire are due lower plant and soil water potentials on burned sites (DeJong and MacDon 1975), climatic conditions and the attraction of grazers to recently burned ar (Gartner et al. 1986), site productivity (Dix 1960; DeJong and MacDonald 19 Whisenant and Uresk 1990), the presence of significant amounts of native war season species (Schacht and Stubbendieck 1985), and topographic location. T response to fire also varies depending on the season in which the fire occurs (D 1960; Coupland 1973; Engle and Bultsma 1984; Schacht and Stubbendie 1985; Gartner et al. 1986; Steuter 1987; Whisenant and Uresk 1990; Redma et al. 1993). Fall burning has the most adverse effect on herbage production, voring cool-season species over warm-season species. Spring burns decre some cool-season species (e.g., Kentucky bluegrass and green needlegrass) a increase others (e.g., western wheatgrass, blue grama, and buffalo grass). though fire may reduce standing crop, community composition and divers

patterns following fire are indicative of a grassland well adapted to its effects (Biondini et al. 1989). The range of variability in plant composition between spring, summer, and fall burns is similar to that caused by annual fluctuations in weather (Biondini et al. 1989). Complete fire suppression results in accumulation of mulch, conditions that favor cool-season exotic species (Ode et al. 1980; Whisenant 1990) and most likely accounts for the active invasion of woody plants in the southern portion of the northern mixed prairie (Kaul and Rolfsmeier 1993).

Sandhills Prairie

Sandhills prairie (Küchler 1985) originally encompassed approximately 7 million ha. The Nebraska Sandhills prairie accounts for approximately 5 million ha of this total, while most of the remainder occurs in central Kansas. The Nebraska Sandhills prairie developed on the largest stabilized sand dune complex in the Western Hemisphere (Bleed 1990). The substrate has often not undergone sufficient change to be classified as a soil, but those that have developed are primarily fine sands or fine sandy loams.

Warm-season grasses dominate primary production, and a distinct community zonation exists based on slope position (Barnes and Harrison 1982). Dominant grasses include prairie sandreed, sand bluestem, big bluestem, little bluestem, blue grama, hairy grama, needle-and-thread, and sand dropseed (Weaver 1965). Sedges are ubiquitous even though they make up only a small component of standing crop. Forbs, such as western ragweed, skeletonweed, and plains sunflower, may represent 10 to 25 percent of the regional species standing crop. In addition to regional variations in dominant species, substantial differences in species composition occur between uplands, slopes, and lowlands (Barnes et al. 1984). Presumably because of recent fire suppression, woody plants are actively invading, especially along the prairie margins (Steinauer and Bragg 1987; Steuter et al. 1990a).

The sandhills prairie has been subjected to large herbivore grazing, at least during more stabilized periods. Bison occurred in the Nebraska Sandhills for at least the last eleven thousand years (Loope 1986). Currently, cattle grazing is the principal use of sandhills prairie. As with other mixed prairie communities, grazing reduces standing crop (Bragg 1978). In general, bunchgrasses are less tolerant of grazing than rhizomatous species. For example, fragmentation of little bluestem plants into scattered clumps with high tiller density occurs with heavy grazing pressure (Butler and Briske 1988). Moderate and heavy grazing also effectively prevent litter accumulation. While this accumulation has no significant effect on overall standing crop, it may affect individual species (Potvin and Harrison 1984). Among the sandhills plant species most heavily grazed are sand bluestem, indian grass, prairie sandreed, blue grama, western wheatgrass, needle-and-thread, and switchgrass. Sandhill muhly and sand dropseed do not appear to be affected by grazing (Bragg 1978). The current bunchgrass composition of sandhills prairie appears dependent on fire exclusion (Pfeiffer and Steuter 1994) since large herbivores intensively graze burned bunchgrasses such as little bluestem.

Historic fires in the Nebraska Sandhills prairie occurred as frequently as every four to five years (Bragg 1986). As in other mixed prairie types, fire causes an initial decline in plant standing crop (see table 4.1) although the decline may not persist longer than one to two years (Bragg 1978), depending largely on weather conditions. Both standing crop and species composition are variously affected by different combinations of burning, grazing, and topographic location. The decline in standing crop is greater with combined fire and grazing than with fire alone (Bragg 1978). Burning also may significantly affect surface stability in the sandhills because fall burns leave the soil surface exposed for several months. A large reduction in bunchgrass composition due to the interaction between fire and grazing may increase the risk of wind erosion (Pfeiffer and Steuter 1994).

Sand lovegrass, sandhill muhly, small soapweed, and sand bluestem are among the species that decline with burning (Bragg 1978). Other species, including Missouri spurge and plains sunflower, increase with burning, as do interstitial forbs (Pfeiffer and Steuter 1994). Sand dropseed cover is increased with summer burns, while the standing crop of larger bunchgrasses is reduced. Rhizomatous grasses maintain or increase their standing crop following fires in years with normal or above-normal precipitation.

Southern Mixed Prairie

The original extent of the southern mixed prairie encompassed approximately 24 million ha. It includes the bluestem-grama and mesquite-buffalo grass associa- tions of Küchler (1985). Soils typically range from loams to clays. A wide variety of warm-season grasses of mid- to short stature increasingly dominate as one proceeds from Kansas to Texas. Shrubs become a significant component on the Rolling Plains of Texas.

The Kansas-Oklahoma component is dominated by blue grama, sideoats grama, western wheatgrass, little bluestem, junegrass, green needlegrass, porcupine grass, Kentucky bluegrass, tall dropseed, Canada wildrye, and sedges (Weaver and Albertson 1956; Wright and Bailey 1982). Forbs make up approximately 25 percent of total standing crop and include locoweed, heath aster, aromatic aster, penstemon, scarlet gaura, annual sunflower, and dotted gayfeather. Dominant invaders include yellow sweetclover, gumweed, and foxtail barley. Di-

versity is relatively high: 236 vascular plants were recorded in a 259-ha site in southern Nebraska (Nagel 1979).

The Rolling Plains and western Edwards Plateau regions of the Texas component are characterized by a scattered overstory dominated by honey mesquite, with lotebush an important subdominant. The herbaceous component is variously dominated by buffalo grass, sideoats grama, tobosagrass, little bluestem, and Texas wintergrass. Many annual forbs and some annual grasses—bitterweed, Carolina canary grass, and little barley—are abundant during wet winters. Perennial forbs include blanket flower, primrose, lazy daisy, lamb's quarter, butterfly weed, sunflower, Patagonian plantain, nightshade, and scarlet globe mallow (Wright and Bailey 1982). Breaks throughout the Rolling Plains region contain large amounts of redberry juniper (Wright and Bailey 1982). The western Edwards Plateau is similar in composition although common curlymesquite, a stoloniferous shortgrass like buffalo grass, is also prevalent.

Drought and topography affect species composition. Mesic conditions favor taller grasses (e.g., little bluestem and big bluestem), and drier conditions favor shorter grasses (e.g., sideoats grama, blue grama, and buffalo grass) (Albertson and Tomanek 1965; Mihlbacher et al. 1989). Disturbances, such as grazing and wallowing of bison and prairie dog diggings, increase grassland diversity (Collins and Barber 1985).

As in other mixed prairies, most studies indicate that grazing reduces standing crop (Milchunas and Lauenroth 1993), although there are exceptions in which long-term changes appear unrelated to grazing (Mihlbacher et al. 1989). In most instances, mid- and tall grasses decrease with grazing while short grasses, especially buffalo grass, increase as much as 90 percent. While heavy grazing reduces standing crop, moderate grazing may only slightly reduce or even increase production over ungrazed areas (Tomanek and Albertson 1957). With no grazing, however, litter accumulation may cause grass-stand degeneration and reduced production. In the absence of fire, ashe juniper, redberry juniper, and honey mesquite invade grasslands and suppress the herbaceous component, thus lowering forage availability (Wink and Wright 1973; Steuter and Wright 1983).

One effect of the interaction of fire and grazing is that reported by Ring et al. 1985. Their study showed that an area repeatedly grazed throughout the growing season resulted in overgrazed patches within a matrix of lightly to ungrazed pasture. Subsequent fires in these patchy fuels would burn unevenly and result in a patchy burn that has been hypothesized to increase prairie diversity (Biondini et al. 1989).

For the Kansas-Oklahoma component, most of the dominant grass species are tolerant of fire and may require two to three growing seasons to recover (Launchbaugh 1973; Nagel 1983). Summer fires are most detrimental, followed by spring and then by fall burning. Buffalo grass, blue grama, sideoats grama, and Kentucky bluegrass are most severely reduced with spring burning in Kansas and

Oklahoma (Launchbaugh 1964). At least three growing seasons are required for recovery of these species to preburn amounts. Decreases were greatest where litter was heaviest (Launchbaugh 1964). Several broad-leaved plants increase with spring burning, including western ragweed (Hopkins et al. 1948). In Texas, species that seem to thrive up to about three growing seasons after a fire include vine mesquite, tobosagrass, Arizona cottontop, little bluestem, plains bristlegrass, and Texas cupgrass (Wright 1974). Generally, these are the species that accumulate the most mulch and thus would be most adversely affected by such an accumulation (Launchbaugh 1964, 1973). A species's response to fire is also affected by climate. Most grasses tolerate fire during years with normal to above-normal precipitation but are adversely affected during dry years (Hopkins et al. 1948; Wink and Wright 1973; Wright 1974). When subjected to fire in dry years, some species, such as sideoats grama, Texas wintergrass, and little bluestem, have been shown to decrease productivity by as much as 40 to 58 percent, requiring up to three years to recover to preburn standing crop. Yet during wet years, little bluestem increased as much as 81 percent (Wink and Wright 1973). While fire is a natural component of the mixed prairie, burning more frequently than every five to eight years will result in a decline in standing crop of the dominant herbaceous species (Sharrow and Wright 1977; Neuenschwander et al. 1978). The response to burning also depends on species composition. Where annual, cool-season grasses are few, Texas wintergrass standing crop declines. Where cool-season grasses are abundant, fire increases production of this species, although the increase is greater with fall than with spring burning (Whisenant et al. 1984). The standing crop of cacti, an abundant group of plants in the southern mixed prairie, is also reduced by burning (Wright and Bailey 1982).

In the absence of burning and grazing and the concomitant increase of mulch, significant reductions in the Kansas-Oklahoma southern mixed prairie occur for the dominant grasses (e.g., blue grama, buffalo grass, and sideoats grama) while other species (e.g., sedges, smooth brome, and tall dropseed) increase dramatically (Nagel 1994). In the Texas mixed prairie, however, fire is particularly important as a control against the invasion of honey mesquite, juniper, and other woody species (Wink and Wright 1973; Neuenschwander et al. 1978; Steuter and Wright 1983). Presumably because of fire suppression efforts, honey mesquite, for example, is considerably more dense now than is indicated from historical records (Wright et al. 1976). The invasion of these woody species reduces forage, causes a deterioration of the native prairie habitat, and is of sufficient concern that various techniques are used in their control (e.g., Bryant et al. 1983).

Contemporary management has altered the mixed prairie structure, function, and occurrence by reducing or eliminating keystone species, cultivating large areas, redistributing surface water and groundwater, altering fire frequency, developing extensive transportation corridors, introducing exotic species, promoting the development of woodlands, and establishing long-term management unit boundaries.

Extent

As a result of human activities, mixed prairie has been substantially reduced (Samson and Knopf 1994). Klopatek et al. (1979) estimated the reduction of Küchler's potential mixed prairie vegetation based on a set of land-use variables collected by county during the late 1960s (see table 4.2). Their estimates do not account for the expansion of cropland that occurred during the 1970s nor for the conversion back to perennial vegetation that occurred under the Conservation Reserve Program in the 1980s. We compared the Klopatek et al. (1979) local data with a recent analysis of remotely sensed data (see table 4.2) (U.S. Geological Survey 1993). These data were derived from the land-cover characteristics database created at the EROS (Earth Resources Observation System) Data Center (U.S. Geological Survey 1993). The database portrays regions composed of similar land-cover mosaics as defined by a multitemporal, advanced very high resolution radiometer normalized vegetation index obtained from a National Oceanic and Atmospheric Administration satellite during 1990 and attributes such as terrain, climate, and ecoregion (Loveland et al. 1991). The land-cover product has been resampled from a 1.1-km^2 resolution to a 1-km^2 resolution. Although 159 land-cover types are defined in the database, we selected only those identified with native vegetation typical of the five mixed prairie types of Küchler (1985).

Table 4.2
Percent of remaining mixed prairie area

	Percent Remaining	
Mixed Prairie Type	Klopatek et al.	EROS
Northern mixed		
Wheatgrass-bluestem-needlegrass	31	17
Wheatgrass-needlegrass	64	61
Sandhills	94	72
Southern mixed		
Bluestem-grama	35	8
Mesquite-buffalo grass	73	58

Source: Based on estimates by Klopatek et al. 1979 and the Eros Data Center, Sioux Falls, South Dakota 1995.

The lower estimates of extant mixed prairie provided by the EROS data set may be the result of additional mixed prairie loss, although it is also possible that they represent differences due to masking of small tracts and edges when analyzed at the resolution used. This is suggested by the relatively large differences between the estimates in the two most intensively farmed types (wheatgrass-bluestem-needlegrass and bluestem-grama). The EROS data emphasize the larger, less-fragmented tracts of remaining mixed prairie, while the estimates of Klopatek et al. (1979) include large native prairie tracts as well as small isolated tracts surrounded by croplands. These two estimates have significantly different implications for conservation, since ecosystem function within expansive grasslands differs greatly from small grasslands surrounded by croplands (Shafer 1995).

Function and Composition

The percent of land surface remaining in native mixed prairie vegetation is relatively large compared to the tallgrass prairie. But this is a very different mixed prairie ecosystem than the one European settlers took from the Plains Indian cultures. The native vegetation is still a dynamic reflection of the interactions between climate, soils, weather, grazing animals, and fire. But the present grazing and fire regimes are determined by a different set of ecosystem rules. These new rules operate at smaller (individual landowner) and larger (national and international commerce) scales than in the mixed prairie of five hundred years ago. Relatively few species have been extirpated by current management practices. However, major changes in community composition and landscape patterns have resulted from the replacement of bison with cattle and the imposition of croplands, transportation corridors, and urban areas. Although changes that followed European settlement have significantly reduced critical grassland and wetland habitats, they have significantly expanded woodland habitats. Mixed prairie woodlands are expanding due to changes in river flows (Johnson 1994), grazing and fire regimes (Steuter et al. 1990a), and directly from shelter-belt planting. The presence of many large browsing mammals in the pre-Holocene fossil record suggests that woodlands were more common in the mixed prairie region prior to the arrival of humans twelve thousand years ago or more. We expect that mixed prairie will continue to undergo change and that humans will continue to manage the changing ecosystem.

The semiarid climate of the mixed prairie ecosystem places a premium on the linkages between the uplands and the riparian and wetland parts of the landscape.. The major functional linkage between uplands and lowlands is water. Highly mobile and sedentary species using the mixed prairie were adapted to the temporal and spatial patterns of available moisture. Surface water storage,

drainage for crop production, and flood control have affected plants and altered the landscape pattern too rapidly for many migratory species to adapt. Thus water conservation is central to many issues in conservation.

Conservation

Our understanding of mixed prairie ecology and management suggests a conservation strategy based on land management that acknowledges the ecosystem's adaptations to limited water availability, grazing, and periodic fire. Demands on water resources will continue to exceed supplies in the mixed prairie region. Municipalities and recreation interests will increasingly compete with wildlife conservation interests for water currently allocated to agriculture. Groundwater, as well as surface water supplies, will need to be used more efficiently, with emphasis on water quality. Mixed prairie communities can play a natural role in meeting these water quantity and quality objectives. When properly managed, mixed prairie provides a renewable source of high-quality water, food, and habitat for a wide range of species and uses. Although limited in extent, wetland and riparian areas will continue to be critical to a healthy mixed prairie ecosystem.

Most of the remaining mixed prairie is grazed by cattle, although bison ranching is becoming more common. Large herbivore grazing is a required process for sustaining mixed prairies. Prairie diversity and productivity may be adversely affected by the absence of grazing or when grazing is too intense or occurs at inappropriate times of the year or for too long a period of time. The dominant plants, whether cool- or warm-season grasses, require regular grazed and ungrazed periods during the growing season for optimum future growth. Either continuous heavy grazing or excessive litter accumulation may adversely affect individual species and reduce overall productivity and diversity. By physically disrupting the soil surface, grazing may increase erosion although conditions for plant establishment that enhance long-term diversity may be able to be improved. Thus grazing, whether for livestock production or natural area management, is an appropriate management tool in the mixed prairie.

Fire is also important to mixed prairie conservation, although it is used less often today than it is believed to have occurred in the past. Like grazing, the season, intensity, and frequency of burning are variables that need to be considered when using fire as a management tool. When used appropriately, fire can prevent or slow woody plant invasion and improve forage for grazing animals, although at some loss of standing crop. Fire is also important for establishing seedlings, thereby assisting in the maintenance of long-term plant diversity. Land management using combined fire and grazing is widely applied in the Kansas Flint Hills and has maintained a productive grassland for over one hundred years. The expansion of woodlands, which results from a reduction in fire frequency, may provide opportunities for offsetting habitat declines in other regions (i.e., eastern woodland bird habitat). However, this may lead to hybridization between previously disjunct populations, the cosmopolitanism of the landscape (Knopf 1986), and loss of biological diversity at some scales. These are effects that need to be considered in conservation planning on a regional scale.

The vagaries of climate dictate that a dispersed and redundant system of appropriate upland and wetland habitats be available for both migratory and nonmigratory species. It should be possible to manage for both if these landscapes are appropriately managed by grazing and fire and integrated by the critical water resource (see fig. 4.1). The mixed prairie is predominantly privately owned and managed. Except for the sandhills prairie, cropland acreage is regionally similar to perennial grassland. A successful conservation strategy will need to move land management of croplands, grasslands, and wetlands toward a more conservative use of resources. Several private-public efforts with this objective in mind are underway through the U.S. Fish and Wildlife Service Partners for Wildlife Program and through joint ventures by landowners, state and federal agencies, and private conservation organizations.

Mixed prairie conservation is best approached with a humble and open mind rather than a dogmatic focus on a single point in time. Change is a constant and usually unpredictable characteristic of the ecosystem. It is the species diversity of mixed prairie that gives the ecosystem resilience and can also provide the foundation for a resilient human economy. Conservation of the mixed prairie will be

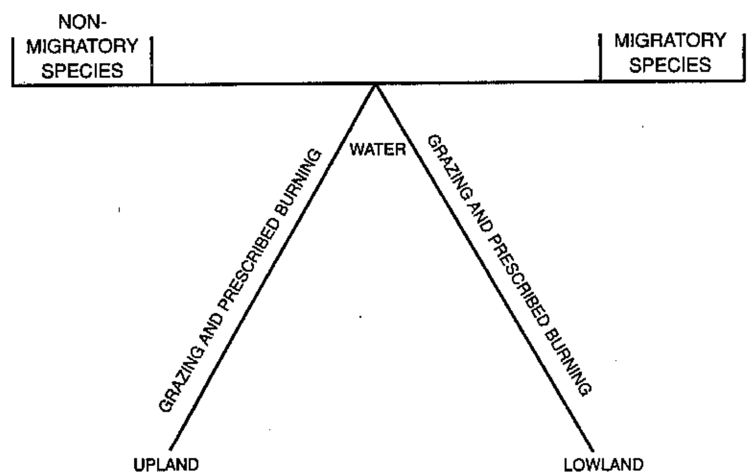

Fig. 4.1 Schematic representation of a conservation program that acknowledges the critical role of water resources in balancing both migratory and nonmigratory species protection.

achieved by monitoring the biological community and being willing to change management techniques to maintain its diversity.

Acknowledgments

We acknowledge the support of our respective institutions in this effort. B. K. Wylie and D. D. DeJong of Augustana College, and the EROS Data Center, Sioux Falls, South Dakota, provided information for the remote-sensed estimates of current mixed prairie extent. S. Winckler and D. Sutherland provided a critical review and technical support for the chapter. Omissions or errors, however, remain solely our responsibility.

All or portions of seven chapters appeared in the *1995 Transactions of the North American Wildlife and Natural Resources Conference*, published by the Wildlife Management Institute, Washington, D.C.

Library of Congress Cataloging-in-Publication Data

Prairie conservation: preserving North America's most endangered ecosystem / edited by Fred B. Samson and Fritz L. Knopf; foreword by E. Benjamin Nelson

p. cm.

Includes bibliographical references and index.

ISBN 1-55963-427-8 (cloth). — ISBN 1-55963-428-6 (paper)

1. Prairie conservation—North America. 2. Ecosystem management—North America. I. Samson, Fred B. II. Knopf, Fritz L.

QH77.N56P735 1996

333.74'16'097—dc20 96-11227

CIP

Printed on recycled, acid-free paper ⊛

Manufactured in the United States of America

10 9 8 7 6 5 4 3 2 1

Contents